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*Published in:*  
PsyArXiv Preprints

*DOI:*  
[10.31234/osf.io/t2j7p](https://doi.org/10.31234/osf.io/t2j7p)

**IMPORTANT NOTE:** You are advised to consult the publisher's version (publisher's PDF) if you wish to cite from it. Please check the document version below.

*Document Version*  
Early version, also known as pre-print

*Publication date:*  
2019

[Link to publication in University of Groningen/UMCG research database](#)

*Citation for published version (APA):*

Heininga, V. E., Dejonckheere, E., Houben, M., & Kuppens, P. (Accepted/In press). Sociomarkers of anhedonia in MDD. *PsyArXiv Preprints*. <https://doi.org/10.31234/osf.io/t2j7p>

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Sociomarkers of anhedonia in MDD

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## Abstract

**Background:** Anhedonia is one of the two core symptoms of MDD, described as the decreased ability to experience pleasure in daily life. We aimed to describe anhedonia in everyday life of patients with Major Depressive Disorder (MDD), and investigate its link to social stress. We semi-randomly sampled anhedonia and social stress ten times a day, for seven consecutive days, by means of Experience Sampling Methods in the daily life of 53 MDD patients. **Results:** Multilevel analyses showed that anhedonia was less severe when patient were in company of others (versus being alone). Social stress was linked to anhedonia, both concurrently and prospectively. Albeit less strongly, anhedonia also prospectively predicted increases in social stress. **Conclusions:** Experiencing an increase in social stress makes it harder for depressed patients to experience pleasure in both current and future activities, suggesting that social stressors might put MDD patients at risk for the development of anhedonia.

*Keywords:* Depression; Consummatory anhedonia; Liking impairment; Ecological Momentary Assessment (EMA)

*Word count:* 6459

## Sociomarkers of anhedonia in MDD

### **Background**

Major Depressive Disorder (MDD) is a prevalent disorder that has become the leading cause of disability worldwide (Organization & others, 2017). Patients are diagnosed with MDD when they meet the criteria for at least four out of nine depressive symptoms in combination with at least one of the two core MDD symptoms: depressed mood and anhedonia. Compared to depressed mood, anhedonia, which reflects a decreased ability to experience pleasure, has remained relatively understudied. The aim of the current study is to examine the (social) factors that drive anhedonia in the daily lives of individual suffering from depression.

To help identify those factors, it is worthwhile to start from the adaptive function of pleasure and anhedonic states. From an evolutionary perspective, in situations that decrease fitness, pleasure experiences are harmful (Nesse & Ellsworth, 2009). Temporary difficulties in experiencing pleasure in situation that decrease fitness is thus healthy and adaptive (Carver, 2015; Kashdan & Rottenberg, 2010; Nesse & Ellsworth, 2009; Panksepp, Solms, Schläpfer, & Coenen, 2012). Evolutionists have come to consensus that mental disease occurs when the capacity to cope with the situational context is impaired (Gluckman, Beedle, Buklijas, Low, & Hanson, 2016). Sadness or low mood are thus considered functional and adaptive response mechanisms to cope with situational changes, which are dysfunctional in MDD (for a critical review, see: Hagen, 2011; Nettle, 2004, 2009).

Nevertheless, evolutionists are inconclusive about the exact underlying mechanism of depressed states such as anhedonia. Whereas some suggest that the ability to experience a depressed state is a mechanism to stop a prolonged separation distress responses after the death of a loved one (Watt & Panksepp, 2009); others argue that it evolved to minimize the risk in the face of social exclusion [N. B. Allen and Badcock (2003); possibly via an increased

adaptive reasoning about social competition (P. Badcock & Allen, 2003)], or repeated social failure experiences (Price, Sloman, Gardner, Gilbert, & Rohde, 1994). Albeit for different reasons, multiple evolutionary theories thus suggest a relation between depressive symptoms and social stress.

In line with evolutionary reasoning, social relationships are repeatedly linked to well-being (Cohen, 2004; Deindl, Brandt, & Hank, 2016; Kawachi & Berkman, 2001), as well as to depressive symptoms. Supportive social relationships, for example, appear to have the power to alleviate depressive symptoms (e.g., Hallgren, Lundin, Tee, Burström, & Forsell, 2017; for a systematic review, see: Santini, Koyanagi, Tyrovolas, Mason, & Haro, 2015), especially when the support is provided by significant others (Muramatsu, Yin, & Hedeker, 2010; Pettit, Roberts, Lewinsohn, Seeley, & Yaroslavsky, 2011; Teo, Choi, & Valenstein, 2013; e.g., family and friends; Thoits, 2011). Interestingly, these protective effects seem to reside mostly in the eye of the beholder, as subjective appraisal of the social environment is typically more predictive than the actual status quo (Santini et al., 2015). Conversely, lower levels of social support are associated with the presence, onset or development of depression (Santini et al., 2015), and compromised survival (Holt-Lunstad, Smith, & Layton, 2010).

Indeed, a recent meta-analytic review aimed to determine the extent to which social relationships influence risk for mortality showed that social relationships had a larger effect on mortality rates than smoking, excessive drinking, lack of physical activity, and obesity (Holt-Lunstad et al., 2010).

Turning to well-being during moments of social interaction, momentary Positive Affect (PA) is typically higher when individuals were in company of others versus when they were not (e.g., Bernstein, Zawadzki, Juth, Benfield, & Smyth, 2018; for a systematic review and meta-analysis, see: Liu, Xie, & Lou, 2018). The higher levels of PA in social contexts is explained via interpersonal theory (Liu et al., 2018), which states that company of others could signal social acceptance which, in turn, would increase PA (Hopwood, Wright, Ansell,

& Pincus, 2013). It remains unknown whether the inverse holds for anhedonia, that is, that anhedonia is lower when in company of others, and that the subjective appraisal of possible social rejection or exclusion would increase anhedonia. The characteristics of social relationships have been found predictive of depressed mood, both in quantity (i.e., occurrence of social context) and quality of social interactions (e.g., providing high levels of social support; Liu et al., 2018; Pemberton & Tyszkiewicz, 2016). However, most studies focused on sadness or negative mood states, and only a few included pleasure experiences or positive mood states.

In total, to our knowledge, three ESM studies investigated social markers for positive mood states in daily life (Brown, Strauman, Barrantes-Vidal, Silvia, & Kwapil, 2011; Clark & Watson, 1988; Vranceanu, Gallo, & Bogart, 2009). In the first study, a robust association was reported between high Positive Affect (PA) and reported social interactions, and physically active social events in particular (Clark & Watson, 1988). In the second study, more social contact and a greater sense of social closeness was associated with higher PA, especially in individuals that suffered from elevated levels of depression (Brown et al., 2011). Furthermore, lagged analyses showed that closeness predicted improvement in PA at the next time point (approximately two hours later), but not the other way around (Brown et al., 2011). Finally, the third study focused on social conflict, a concept closely related to social stress, and found that social conflict was associated with low PA in daily life (Vranceanu et al., 2009). Although these three ESM studies focused on PA, and PA closely relates to anhedonia, however, the absence of PA does not necessarily imply the presence of anhedonia (i.e., difficulty to experience PA).

Clearly, social factors play an important role in depression, and may well be key in the development and persistence of anhedonia. The above described evolutionary theories and empirical research findings indicate that feelings of anhedonia might fluctuate as a function of social company, and the subjective appraisal of social stress.

**The present study.** The aim of the present study was to investigate the within-person association between social stress and anhedonia, using ESM. ESM data were obtained through smartphones, on which participants reported what they were doing, with whom, and how they felt on ten time points a day, for seven executive days. Anhedonia was measured in a momentary fashion, by asking the participants to rate the degree to which they found it difficult to experience pleasure in momentary activities at each assessment.

Participants were also asked to rate their momentary social stress, operationalized as relationship quality and fear of abandonment.

After a short description of sample demographics, we describe the levels of momentary anhedonia across contexts, explore its Intra Class Correlation (ICC), and test for diurnal pattern throughout the day. Next, we test the following three hypotheses:

1. Momentary anhedonia in MDD is lower when patients are in company of others (versus alone), especially significant others.<sup>1</sup>
2. Higher levels of subjective social stress are concurrently associated with higher levels of anhedonia.
3. Higher levels of subjective social stress are associated with higher levels of anhedonia on the next assessment, and not the other way around.

## **Methods**

The patients of this study consisted of 53 patients (both outpatients and inpatients) diagnosed with MDD (and possibly other psychiatric diagnosis). This is a subset drawn from a larger study on emotion dynamics in people with Major Depressive Disorder, Borderline Personality Disorder, Bipolar Disorder, and people without psychological complaints.

<sup>1</sup>This was formulated in the pre-registration as “In company of significant others, levels of anhedonia are lower (versus when being alone, and versus in company of non-significant others). (directional)”

Clinicians screened for patients at intake in three Belgian psychiatric wards: KU Leuven hospital UPC Sint-Anna; UPC De Weg/ Onderweg; and the Broeders Alexianen Tienen hospital ward Prisma II, after which a clinically trained researcher interviewed the eligible patients using the Dutch version of the Structured Clinical Interview for DSM axis-IV Axis I disorders (SCID-I) and the Borderline Personality Disorder (BPD) subscale of the DSM axis-II disorders (SCID-II).<sup>2</sup> Patients were enrolled if they met the criteria for one of the mood disorders, and excluded if they were acutely psychotic; acutely manic; addicted; or diagnosed with a (neuro-)cognitive disorder.

After enrollment, patients signed informed consent and were asked to, among other things, fill out baseline questionnaires. The next day, after receiving two trial ESM-assessments at 6.30 PM and 8.00 PM, the EMA-part of the study started. ESM assessments were semi-randomly presented on a Motorola Defy Plus smartphone device, using a custom made ESM software program MobileQ (Meers, Dejonckheere, Kalokerinos, Rummens, & Kuppens, in preparation), ten times a day between 9.30 am and 9.30 pm, for seven days, resulting in a 66 minute interval on average (i.e., maximum 70 assessments per person). The total number of questions asked per assessment was 27 (eight on emotions; one on social expectancies; four on emotion regulation; five on context; nine on psychiatric symptoms). Questions were clustered, the clusters were administered randomly, and questions within cluster random as well. Participants had 90 seconds to respond to a beep. After the 90 seconds, no reminders were sent, and missed assessments could not be caught up. Patients received 35,- Euros for a compliance rate above 75%, and 5,- Euros less for

<sup>2</sup>The SCID-I is an extensive semi-structured diagnostic interview designed to determine the presence of symptoms for a range of disorders, including depression (M. B. First, Spitzer, Gibbon, Williams, & others, 2002; M. First, Gibbon, Spitzer, Williams, & Benjamin, 1997). The SCID was administered by a trained clinician and, based on a random sample of seven audio recordings of these clinical interviews, a second independent trained clinician rated symptoms and diagnoses of a random subsample of seven



interviews of patients and healthy controls. The interrater reliability between the two raters was excellent (Cohen's  $\kappa$  = .93 on diagnosis level and Cohen's  $\kappa$  = .92 on symptom level).

every 10% lower.

## **Data exclusions and subsample selection**

From the initially 90 patients enrolled, three quit during the baseline assessments. Two patients had to be excluded because they had malfunctioning devices during the study; and seven others due had a <50% compliance rate. Of the remaining 78 patients, 38 patients were diagnosed with MDD (and possibly other psychiatric diagnoses but not BPD), 20 diagnosed with BPD (and possibly other psychiatric diagnoses but not MDD), and 20 diagnosed with both MDD and BPD. The 20 patients who were diagnosed with BPD but not MDD were excluded from the analyses, leaving 58 patients diagnosed with MDD (of which 20 were also diagnosed with BPD). Of these 58 MDD patients, five were excluded because of past (hypo) manic episodes<sup>3</sup>, leaving a final sample of 53 patients.

## **Measures**

**Momentary anhedonia.** Momentary anhedonia was measured by a newly developed EMA item. At each EMA assessment, patients were asked “To what degree do you find it difficult to experience pleasure in activities at the moment?”, with a sliding scale to answer somewhere between 0 anchored “not at all”, and 100 anchored with “very difficult” The measurement properties of this item were previously explored by Heininga et al., 2018 (V. E. Heininga et al. (2018); see also: <https://osf.io/4bkad/>), and results showed that depressed patients scored significantly higher on momentary anhedonia compared to the control group ( $\Delta M = -46.48$ , 95% CI[**-47.32, -45.64**],  $t(5,885.56) = -108.40$ ,  $p < .001$ ). The

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<sup>3</sup>Please note that this is a deviation from what was preregistered, as it was initially left unnoticed that 5 MDD patients had also reported (hypo) manic episodes by which they qualify for Bipolar Disorder instead of MDD. To be able to still investigate anhedonia MDD (and possibly BPD, but not Bipolar Disorder) we decided to deviate from our preregistration and remove these patients

correlation between the clinician-rated measure of loss of interest or pleasure in things the patient usually enjoyed over the last two weeks, and the median of patients' degree to which they found it difficult to experience pleasure in activities at ten semi-random momentary assessment in the two weeks that followed after baseline SCID diagnosis was  $r = .80$ , 95% CI [.71, .87],  $t(85) = 12.46$ ,  $p < .001$ .

**Social company.** Patients were asked "Who are you with at the moment?", with answer categories Alone; With partner; With friend(s); With family members; Colleague(s); Acquaintance(s); With therapist(s); With stranger(s). We recoded these answers into: being alone (0); being in company of significant others (i.e., partner, friends, or family) (1); and being in company of non-significant others such as colleagues, therapist, acquaintances, or strangers (2).<sup>4</sup>

**Fear of abandonment.** To assess patients' fear of abandonment, patients were asked "To what degree do you fear that others will abandon you at the moment?", with a sliding scale ranging from Not at all (0) to Very scared (100).

**Relationship quality.** To assess patients' perceived relationship quality, patients were asked "To what degree do you have a good relationship with others at the moment?", with a sliding scale ranging from Not at all (0) to Very good (100). For ease of interpretation, we reversely recoded this variable.<sup>5</sup>

## Statistical procedures

We investigated our hypotheses by cross-lagged multilevel models in R (Version 3.5.1; R Core Team, 2013), and use Rmarkdown (Allaire et al., —2018) and Papaja (Aust & Barth, <sup>4</sup>This categorization is a deviation from what was pre-registered, as the original plan was to make a dummy variable that reflected 0 if a patient indicated to be in company of significant others, and 1 if patients indicated to be in company of non-significant others.

<sup>5</sup>The reverse coding was not preregistered.

2018) to create a reproducible manuscript. All hypotheses were preregistered on Open Science Framework (<https://osf.io/736qn/>).

To test our first hypothesis, that the company of significant others would go together with lower levels of momentary anhedonia (compared to being alone, or with non-significant others), we performed a one-sided t-test of a random slopes Linear Mixed-Effects Model<sup>6</sup>. Given our sample size, we chose to fit the regression by Restricted maximum likelihood (REML; a form of maximum likelihood estimation which does not base estimates on a maximum likelihood fit of all the information, but another likelihood function to limit the effect of nuisance parameters). First, we regressed momentary anhedonia on the type of company (Equation 1a-b). Next, we used helmert contrasts, to contrast the level of momentary anhedonia when being in company of significant others (1) and being in company of non-significant others (2), versus being alone (0). This was statistically modelled as:

Level 1 (Equation 1a):

$$Anhedonia_i = \beta_0 + \beta_1(Company\ Type_i)$$

Level 2 (Equation 1b):

$$\beta_0 = \gamma_{00} + \gamma_{01} + u_0$$

To test the second hypothesis, that higher levels of subjective social stress are concurrently associated with higher levels of anhedonia, we employed a one-sided test of a random slopes Linear Mixed-Effects Model with assessments nested within subjects. That is, to test for concurrent associations between social stress and momentary anhedonia, we person-mean centered “fear of abandonment” so that it reflected deviations from a person’s own mean, and regressed the level of momentary anhedonia at time point  $t$  on this

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<sup>6</sup>This approach is a deviation from what was pre-registered. We pre-registered to use a one-sided Satterthwaite t-tests, but switched to one-sided test of a random slopes Linear Mixed-Effects Model

person-mean centered “fear of abandonment” variable at time point  $t$  (Equation 2a-c). We reran this model after substituting the “fear of abandonment” by person-mean centered “relationship quality” at time point  $t$  (Equation 2a-c). The two social stressors were separately modelled as:

Level 1 (Equation 2a):

$$Anhedonia_i = \beta_0 + \beta_1(SocialStress_i)$$

Level 2 (Equation 2b-c):

$$\begin{aligned}\beta_0 &= \gamma_{00} + \gamma_{01} + \\ u_0 \beta_1 &= \gamma_{10} + \gamma_{11} \\ &+ u_1\end{aligned}$$

Our third hypothesis, that higher levels of social stress are associated with higher levels of anhedonia on the next assessment - and not the other way around, was again tested by a one-sided test of a random slopes Linear Mixed-Effects Model with assessments nested within subjects, but now using the lagged variables. That is, we predicted the level of momentary anhedonia by the person-mean centered level of fear of abandonment at time point  $t-1$ , while controlling for the person-mean centered level of anhedonia at time point  $t-1$ . Again, we reran this model after substituting the “fear of abandonment” by person-mean centered “relationship quality” at time point  $t$  (Equation 3a-c). This was statistically modelled as:

Level 1 (Equation 3a):

$$Anhedonia_i = \beta_0 + \beta_1(Anhedonia_{i-1}) + \beta_2(SocialStress_{i-1})$$

Level 2 (Equation 3b-c):

$$\begin{aligned}\beta_0 &= \gamma_{00} + \gamma_{01} + u_0 \\ \beta_1 &= \gamma_{10} + \gamma_{11} + u_1\end{aligned}$$

Post hoc, we also explored the effects of the two person-mean centered social stressors when modelled simultaneously in one model:

Level 1 (Equation 4a):

$$Anhedonia_i = \beta_0 + \beta_1(Anhedonia_{i-1}) + \beta_2(Lowrelationshipquality_{i-1}) + \beta_3(Fearofabandonment_{i-1})$$

Level 2 (Equation 4b-c):

$$\begin{aligned}\beta_0 &= \gamma_{00} + \gamma_{01} + \\ u_0 \beta_1 &= \gamma_{10} + \gamma_{11} \\ &+ u_1\end{aligned}$$

Finally, to exclude that social stress on  $t-1$  is associated with momentary “anhedonia” on  $t$  but not the other way around, as outlined in the second part of the third hypothesis, we regressed social stress at  $t$  on the person-mean centered level of momentary anhedonia at time point  $t-1$ , while controlling for the person-mean centered level of the same stressor at time point  $t-1$  (Equation 4a-c). Again, we modelled this separately for low relationship quality and fear of abandonment, as well as for the post hoc model that contained both social stressors:

Level 1 (Equation 4a):

$$SocialStress_i = \beta_0 + \beta_1(SocialStress_{i-1}) + \beta_2(Anhedonia_{i-1})$$

Level 2 (Equation 4b-c):

$$\begin{aligned}\beta_0 &= \gamma_{00} + \gamma_{01} + \\ u_0 \beta_1 &= \gamma_{10} + \gamma_{11} \\ &+ u_1\end{aligned}$$

## Descriptive statistics

**Sample demographics.** Of the total sample of 53 MDD patients, 33 were men (38%). The mean age of the sample was 38.38 (SD =13.08; min-max was 18 and 61 years

old), and 74% of 53 MDD patients had experienced a major depressive episode in the past. On average, patients filled out 60 out of their total 70 assessments (86%; minimum was 54% and maximum was 99%), which were on average 72 minutes spaced apart, and took approximately 122 seconds to complete ( $SD = 37$  seconds).

In addition to current MDD and current anhedonia, approximately 53% also met the criteria for another currently present disorder. The top three of comorbid disorders:

1. Borderline personality disorder (36%);
2. Generalized anxiety disorder (11%);
3. Obsessive Compulsive Disorder (9%).

Compared to patients with “pure” MDD, patients who met the criteria for multiple disorders reported higher levels of momentary anhedonia across study period (respectively 49.85 versus 59.58;  $\Delta M = -9.73$ , 95% CI  $[-17.99, -1.47]$ ,  $t(47.87) = -2.37$ ,  $p = .022$ ).

**Distributions of main variables.** The average mean level of within-person momentary anhedonia was 54.99 (between-person  $SD=15.46$ ); relationship quality 42.52 (between-person  $SD=12.99$ ); and fear of abandonment 49.85 (between-person  $SD=28.29$ ).

On most of the assessments, patients indicated to be without company (i.e., alone), followed by the company of acquaintance(s), and family member(s) (Figure 1).

Visual inspection of Figure 2 shows that the level of anhedonia slightly varied across different types of company.

**Intraclass Correlation Coefficient (ICC) of anhedonia.** The ICC was 0.34, indicating that 66% of the observed variance in momentary anhedonia stems from within-patient differences.



**Diurnal pattern of anhedonia.** Momentary anhedonia showed no linear trend during the day ( $B=-0.83$ ;  $t = -1.65$ ;  $p = 0.106$ ), nor quadratic effects of such ( $B=0.06$ ;  $t = 1.11$ ;  $p = 0.137$ ).

**H1: In company of significant others, levels of anhedonia are lower.**

Results from the Linear mixed model showed an intercept of 52.23, indicating the average level of anhedonia when individuals were alone. Helmert contrasts showed that, compared to being alone, levels of momentary anhedonia were lower when in company of significant others ( $B=5.34$ ;  $t = 3.97$ ;  $p = < 0.001$ ), but not in company of non-significant others ( $B=2.21$ ;  $t = 1.65$ ;  $p = 0.052$ ).

**H2: Higher levels of subjective social stress are concurrently associated with higher levels of Anhedonia.**

As shown in Figure 3, and Table 1 social stress was concurrently associated with the level of momentary anhedonia, both with regard to the fear of abandonment ( $B=0.28$ ;  $t = 6.57$ ;  $p = < 0.001$ ), and relationship quality ( $B=0.21$ ;  $t = 4.98$ ;  $p = < 0.001$ ).

**H3: Higher levels of subjective social stress are associated with higher levels of Anhedonia thereafter, and not the other way around.**

For every point MDD patients reported more fear of abandonment relative to their own average, the level of anhedonia increased 0.11 on the next time point ( $t = 3.08$ ;  $p = 0.002$ ). Similarly, for every point MDD patients reported lower relationship quality relative to their own average, the level of anhedonia increased 0.09 on the next time point ( $t = 3.13$ ;  $p = 0.002$ ). See Figure 4.

As shown in Table 2 and Table 3, the prospective associations between social stressors and anhedonia remained similar when modelled simultaneously in one model.

We did not find support for the second part of the third hypothesis, as the effect was also present the other way around. That is, an increase in the level of momentary anhedonia was followed by a small but significant increase in the level of fear of abandonment on the next time point ( $B=0.04$ ;  $t=2.03$ ;  $p=0.027$ ). The same pattern of weak bidirectionality was present for relationship quality ( $B=0.03$ ;  $t=1.88$ ;  $p=0.034$ ).

## **Discussion**

Central to understanding Major Depressive Disorder (MDD) are the daily life mechanisms that give rise to its core symptoms. Anhedonia is one of the two core symptoms of depression, and we aimed to describe anhedonia in the daily life of MDD patients, as well as its link to social stress. Instead of categorical and in retrospect, we investigated anhedonia in a semi-continuous and momentary fashion using intra-individual time series.

Anhedonia is often referred to as a static or trait-like phenomenon, and diagnosis of anhedonia is often done in binary fashion on its presence in the last two weeks (e.g., SCID-I; M. B. First et al., 2002). Our results showed large intra-individual variation, larger than inter-individual variation, suggesting that anhedonia is fundamentally a dynamic rather than a static phenomenon. Nevertheless, patients who met the criteria for multiple disorders reported higher mean levels of anhedonia across the seven days of study, suggesting that anhedonia is present more often or more severe in the more psychiatrically disordered.

In support of our first hypothesis, compared to when alone, MDD patients felt less anhedonic when in company of their significant others (i.e., family, friends, and partner). The level of anhedonia did not differ from the

level patients experienced when they were in company of non-significant others, suggesting that being alone might be a better sociomarker

for anhedonia than any specific type of objective descriptors of social context (i.e., being with partner; friends; family members; colleagues; acquaintances; strangers). However, being alone is not necessarily be a proxy for anhedonia, it could also indicate that other emotion regulatory mechanisms are at play when patients are alone as supposed to when they are in company of others.

Turning to the concurrent associations, we found that momentary anhedonia was positively associated with the level of social stress patients experienced at the same assessment, supporting our second hypothesis. The effect size was moderate, but is comparable to within-person effect size reported for the more established risk and protective factors for Major Depressive Disorder (MDD), such as physical activity (e.g., Wichers et al., 2012).

Our findings from our first and second hypotheses combined, suggest that risk-effects for comprised mental health are in the eye of the beholder. This finding aligns with the previous finding that showed that how social relationship status was perceived was more predictive of mental health and depressive symptoms than the actual status quo (Santini et al., 2015). Our finding contributes to this literature, as it shows that this phenomena might also hold on the moment-to-moment micro-level in daily life (i.e., on an hourly basis). Future studies into social relationships and anhedonia might want to shy away from objective measures of company, or assess both objective and subjective feelings, as objective contexts likely do not adequately capture the risk component.

With regard to the prospective link between social stress and anhedonia, our third hypothesis was only partially supported. That is, higher levels of social stress were typically followed by a higher level of anhedonia on the next time point, but this effect was also present the other way around. The reversed effect in this bidirectional association is in line with the stress generation model put forward by Hammen (1991). This model holds that depressive symptoms lead to increased marital stress which, in turn, could lead to increased

depressive symptoms and there has been found considerable support for these stress generation patterns (for a see review: Hammen & Shih, 2008). Purely speculative, feeling anhedonic might generate stress in a similar fashion. Difficulty to experience pleasure in activities that were once enjoyable might pose a burden on one's social network as at least part of these activities could be social activities. If one's social network cannot (longer) cope with that burden they may signal reasons for social stress (e.g., distancing themselves). In that case, perceived social stress could lead to more anhedonic feelings. Only one study has yet explored these bi-directional within-person associations, a diary study, showing that stressful event prospectively predicted depressed mood, but not the other way around (Gable, Reis, & Elliot, 2000). However, the reversed effects were statistically significant but relatively small ( $B=.04$ ;  $p=0.03$  for fear of abandonment, and  $B=.03$ ;  $p=0.04$  for relationship quality), indicating that this association is of low relevance or practical significance.

Replication is warranted, but if indeed the reversed effect is negligible, the finding a prospective effect of social stress on anhedonia would open up new opportunities for in-the-moment interventions that aim to counteract depressive symptoms. In that case, it might be worthwhile, for example, to explore whether devoting more attention to social stressors could make cognitive therapy or behavioral activation more effective.

## **Conclusions**

Anhedonia is a dynamic rather than static phenomena, and its severity within MDD patients can vary on an hourly basis. Replication is warranted, but feeling socially stressed puts MDD patients at risk for increased levels of anhedonia, by making it more difficult to experience pleasure in current and short-term future activities.

## **Study limitations**

This study has several limitations. First, we focus on the impairment in the ability to experience pleasure, but anhedonia likely also affects patients' ability to pursue pleasure, and/or learn about pleasure (p.2; e.g., J. M. Bakker et al., 2017; V. Heininga, van Roekel, Wichers, & Oldehinkel, 2017; Römer Thomsen, Whybrow, & Kringelbach, 2015; Wichers et al., 2015). Second, our measure of social stress might have been suboptimal. We addressed all dimensions of the tripartite model (general distress, anhedonic depression and anxious arousal; Clark & Watson, 1991), and cannot disentangle the general distress and anxious arousal in our measures of social stress, particularly fear of abandonment. Perhaps, future studies want to ask for the level of social support provided, and by whom, as the literature suggest that the support component is responsible for the protective effects in depression.

## **Declarations**

### **author's contribution**

V.E.H. developed the study concept. Data collection was performed by E.D. and M.H., and V.E.H. performed the data analysis and interpretation under the supervision of P.K.

V.E.H. drafted the paper, and E.D., M.H. and P.K. provided critical comments and suggestions for revisions. All authors approved the final version of the paper for submission.

### **Ethics approval and consent to participate**

The data was drawn from a larger clinical study on emotion dynamics carried out in accordance with the latest version of the Declaration of Helsinki, and approved by the KU Leuven Social and Societal Ethics

Committee (S58526) and the KU Leuven Medical Ethics Committee (B322201627414).

## **Funding**

The research leading to the results reported in this paper was supported in part by the Research Fund of KU Leuven (GOA/15/003), and the Interuniversity Attraction Poles programme financed by the Belgian government (IAP/P7/06). Vera E. Heininga is a Postdoctoral Fellow of the KU Leuven (Post Doctoral Mandate; 3H170397), and funded by the Ter Meulen grant of The Royal Netherlands Academy of Arts and Sciences (KNAW; grant number TMB17/313). Marlies Houben is a Postdoctoral Fellow of the Research Foundation Flanders (FWO, grant number 12N0817N).



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Table 1

*Concurrent association between social stress and momentary anhedonia*

	Fear of abandonment					Poor relationship quality				
	Estimate	Std. Error	df	t value	Pr(> t )	Estimate	Std. Error	df	t value	Pr(> t )
(Intercept)	55.00	2.12	51.87	25.93	0.00	55.00	2.12	51.87	25.92	0.00
SocialStress_c	0.28	0.04	41.60	6.57	0.00	0.21	0.04	44.67	4.98	0.00

*Note.* SocialStress\_c stands for the person-mean centered level of Fear of abandonment (left part of the table) or Poor relationship quality (right part of the table).

Table 2

*Prospective association between lagged momentary anhedonia on social stress*

	Fear of abandonment					Poor relationship quality				
	Estimate	Std. Error	df	t value	Pr(> t )	Estimate	Std. Error	df	t value	Pr(> t )
(Intercept)	54.78	2.15	51.76	25.42	0.00	54.73	2.16	51.75	25.37	0.00
Anhedonia_1c	0.16	0.03	58.50	5.86	0.00	0.17	0.03	59.71	6.16	0.00
SocialStress_1c	0.11	0.04	47.04	3.08	0.00	0.09	0.03	33.02	3.13	0.00

*Note.* Anhedonia\_1c stands for the lagged (i.e., measured on the previous assessment) person-mean centered level of momentary anhedonia. SocialStress\_1c stands for the lagged person-mean centered level of Fear of abandonment (left part of the table) or Poor relationship quality (right part of the table).

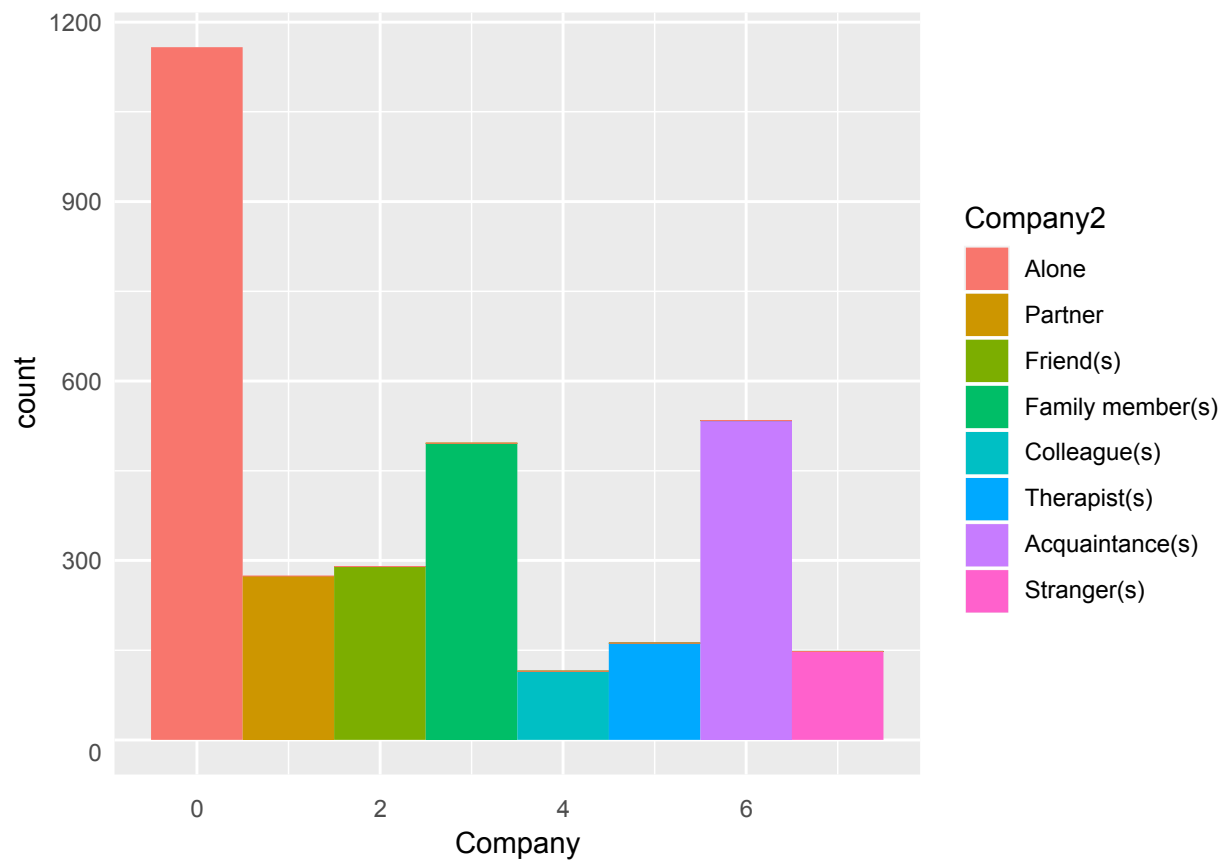


Table 3

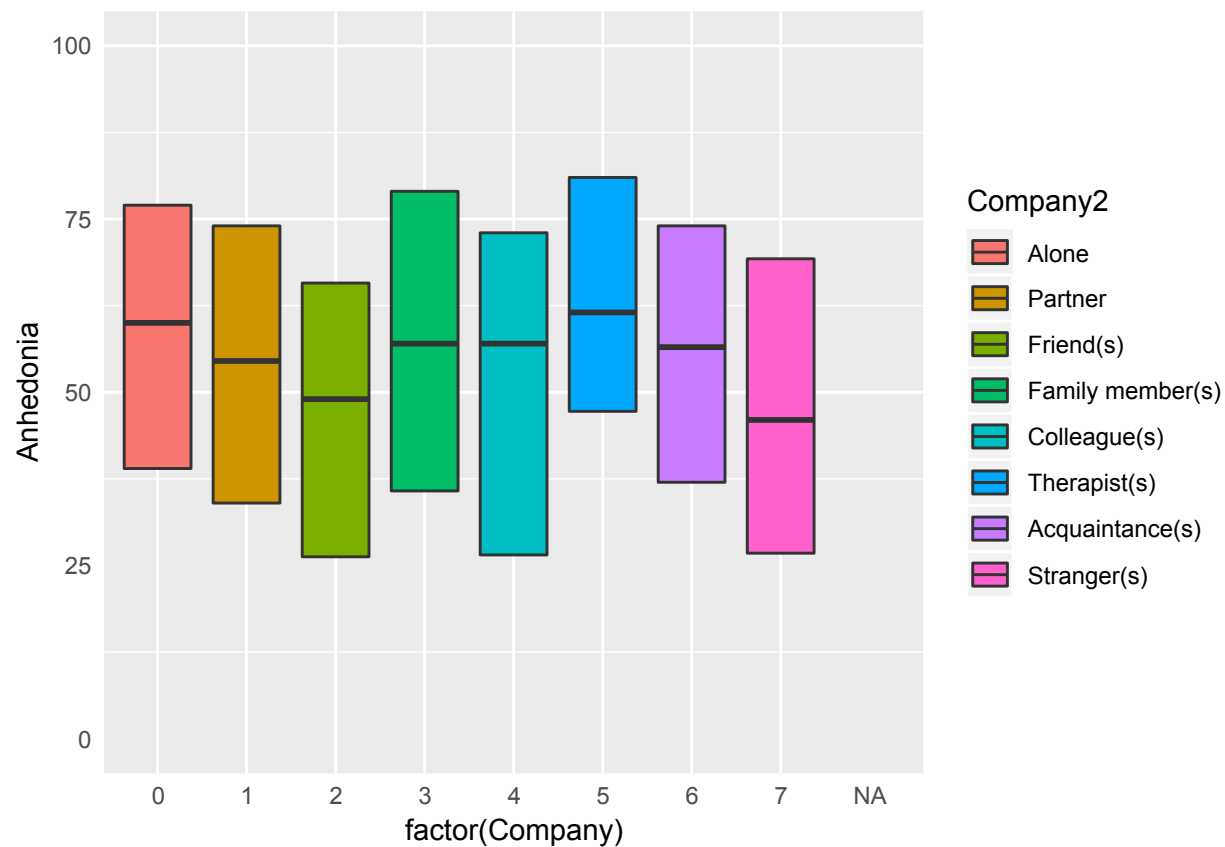
*Exploratory: Prospective association between lagged momentary anhedonia on social stress, modelled simultaneously*

	Estimate	Std. Error	df	t value	Pr(> t )
(Intercept)	54.78	2.16	51.75	25.41	0.00
Anhedonia_1c	0.15	0.03	57.80	5.48	0.00
Abandonment_1c	0.10	0.04	49.17	2.73	0.01
Poor_relations_1c	0.09	0.03	32.85	3.01	0.00

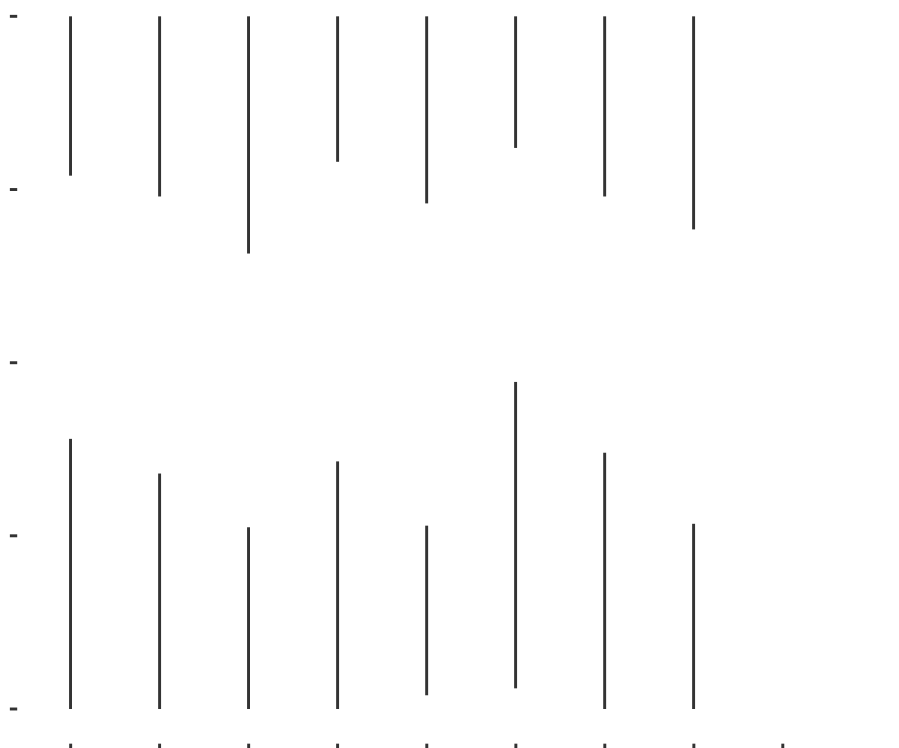
*Note.* Dependent variable is momentary anhedonia. The analysis is exploratory, as it was not preregistrated.

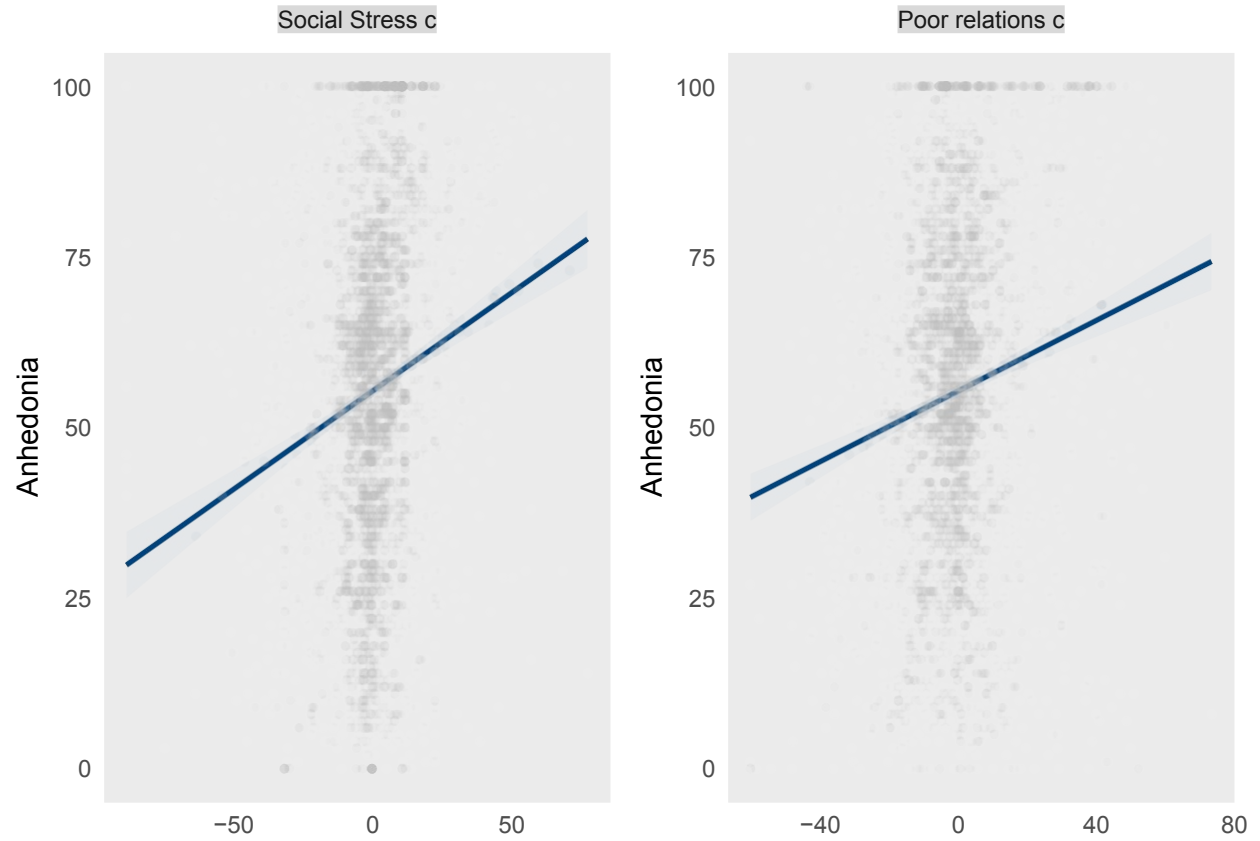


*Figure 1 . Frequency of social company by company type*



*Figure 2* . Distributions of momentary anhedonia across different types of social company





*Figure 3 . Concurrent association between social stress and momentary anhedonia*



*Figure 4 . Prospective association between social stress and momentary anhedonia*